Advanced Micro Devices

AmMap
Filter Design Software for the Am79C30A

User's Guide

12739A/0

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CHAPTER 1

INTRODUCTION

Welcome to version 2.0 of AmMap™ Filter Design software! AmMap is a software tool designed to calculate the coefficients of the X and R user-programmable filters in the Main Audio Processor (MAP) of the Am79C30A Digital Subscriber Controller™ (DSC). This document discusses the operation of the AmMap Filter Design software and guides the user through the different options in the program.

It should be noted that the AmMap software does not model any externally connected hardware. Based on a user-supplied input file, which contains the frequency response for the earpiece or microphone, AmMap calculates the best filter coefficients to compensate for that frequency response.

AmMap FEATURES

- Menu driven
- Commands selected by arrow keys or by first initial
- Menu driven, on-line help
- Converts coefficients into MAP's signed notation
- Normalizes the input file at 1 kHz
- Allows the selection of receiver or transmitter path in the MAP
- Plots filter and total system response
- Plots the MAP's High and Low pass filters' response
- Provides error checking

ABOUT THIS USER'S GUIDE

This guide is divided into four parts:

- Getting Started

  This section contains information on how to set up the AmMap program on your system, including hardware requirements and installing and running AmMap.

- AmMap Commands

  This section describes the way the AmMap program is driven and explains in detail the commands and switches used in the program.

- Input / Output

  This section describes the different forms of input / output within AmMap. It gives the format required for the user-generated input file and the Ear/Mic file.

- AmMap Examples

  This section describes and contains printouts of sample sessions with AmMap.

- Appendices

  These sections contain overviews of the DSC X and R filters and a description of the coefficient representation.

CHAPTER 2

GETTING STARTED

This chapter provides instructions for loading AmMap and describes how to customize it based on the graphics adapter present in the user's computer.

HARDWARE REQUIREMENTS

The following equipment is required to run AmMap software:

- IBM PC-XT, PC-AT, or compatible
- A 5.25-inch diskette drive
- MS-DOS™ or PC-DOS™ version 2.0 or above
- 512K RAM
- Adapter and monitor compatible with one of the following:

  Hercules Graphics Card™
  IBM Color Graphics Adapter™
  IBM Enhanced Graphics Adapter and VGA
  AT&T™ 6300 series

- One of the following printers if hard-copies of the plots are needed:

  IBM Graphics Printer or Proprinter™
  Epson® graphics printers
  Panasonic® KX-P109i

INSTALLING AND RUNNING AmMap

INSTALLING AmMap

The distribution disk includes the following files:

`AmMap.CGA`	Executable code for the IBM Color/Graphics Adapter (CGA card)
`AmMap.EGA`	Executable code for the Enhanced Graphics Adapter (EGA card)
`AmMap.HGC`	Executable code for the Hercules Graphics Card
`AmMap.MON`	Executable code for a monochrome CGA graphics card
`Help.Fil`	This file contains the on-line help text used by the program
`Error.Msg`	Error Messages
`14x9.Fon`	Graphix Tool Box font
`4X6.Fon`	Graphix Tool Box font
`8X8.Fon`	Graphix Tool Box font
`Map1.In`	Input file used in the first sample session
`Map2.In`	Ear/Mic file used in the second sample session
`Map22.In`	Input file used in the second sample session

To install AmMap on your computer hard disk, copy the entire contents of the AmMap diskette into the hard disk in its own subdirectory. The following steps demonstrate the hard disk installation procedure:

1. Place the AmMap diskette in drive A
2. Select the hard disk as the default drive
3. To make a subdirectory called MAP, type:
   `MD Map` ↵
   `CD Map` ↵
4. To copy the contents of the AmMap disk into the new MAP subdirectory, type:
   `COPY A:*.*` ↵
5. Now customize AmMap based on the particular graphics adapter present in your computer.

   If you have a CGA adapter with:

   a color monitor, type:

   `COPY AmMap.CGA AmMap.Exe` ↵

   or monochrome monitor, type:

   `COPY AmMap.MON AmMap.Exe` ↵

   for the EGA adapter, type:

   `COPY AmMap.EGA AmMap.Exe` ↵

   and for the Hercules monochrome adapter, type:

   `COPY AmMap.HGC AmMap.Exe` ↵

   Following is a list of computers and graphic cards supported by AmMap:

   AT&T PC 6300 (CGA)
   Compaq® Portable and DeskPro™ (CGA)
   Heath/Zenith Z150 series (CGA)
   Hercules color card (CGA)
   Hercules monochrome card (HGC)
   IBM Color/Graphics adapter (CGA)
   IBM Enhanced Graphics Adapter or VGA/EGA compatible cards (EGA)
   Tandy® 1000 (CGA)

RUNNING AmMap

From the DOS prompt level, type:

`AMMAP` ↵

When AmMap runs in your system, you will see the start up screen with the AMD logo. When running AmMap from a floppy disk, keep the disk in the drive in order to have access to the help file. You may want to replace the disk with a data disk to save a filter response or when you use the "hex conversion" command.

AmMap program provides on-line help, which is accessed by striking F1. If running from a floppy disk, the AmMap disk must be available in the current drive. If the help file is not found in the default drive, help information will not be provided.

To quit the AmMap program and return to DOS, strike F9.

CHAPTER 3

AmMap COMMANDS

AmMap is a software tool designed to help in the programming of the X and R filters of the Am79C30A. AmMap calculates the coefficients of the X and R filters. Based on a user-supplied input file, it estimates the best X and R FIR filter coefficients to compensate for the frequency response given in the input file.

AmMap is a menu-driven program. From the main menu, the user is able to select any of the available commands and execute them in any order. The inputs to the program are ASCII files created by the user outside the AmMap environment. These files contain the frequency response for which the filter has to compensate. For more detailed information on the input files, please refer to Chapter 4 of this manual.

The user may select any command by highlighting it and pressing ↵. To highlight a command, use the Up and Down direction keys (↑ and ↓) to move the inverse video bar to the desired command, or type the first letter of the command, and then press ↵.

Available commands are:

- Input File
- Find Filter Coefficients
- Optimization
- Plot Filter Response
- Display Filter Response
- Copy to Disk File
- Hex Conversion
- Show System Response

In addition to the previous commands, AmMap supports two toggle switches: Normalize and Gprint. The status of the switches is always shown at the bottom of the Main Menu screen. When a switch is ON, it is highlighted. In the monochrome version, if the switch is ON, arrows are shown on both sides. To change the status of either switch, simply type the first letter of its name.

NORMALIZE

The default setting of this switch is ON. The normalize option causes the amplitude values of the input signal and/or the error to be referenced to 1 kHz.

INPUT SIGNAL

If Normalize is ON when the input file is read, the amplitude value of the input is normalized to 1 kHz. The original amplitude value of the input signal at 1 kHz is saved and is displayed under "offset" in the graphic displays. The normalize switch should always be ON unless the user wishes to provide gain or loss with the X/R filter.

Caution: The X and R filters are not designed to provide gain or loss through the entire band. However, a gain or loss may be provided as long as the coefficients generated are within the –2 to 2 range; otherwise unpredictable results may occur.

ERROR

The Normalize option causes the error signal to be normalized to 1 kHz. If the switch is OFF the error is shown unnormalized.

GPRINT

This switch enables the user to send all graphic plots to the printer. Make sure a printer is on-line before setting this switch to ON. If no printer is available and the switch is set to ON when a Plot command is issued, AmMap displays an error message and returns to DOS. The default setting for this switch is OFF.

Most popular graphic printers are supported. A partial list of supported printers is given in the Hardware Requirements section in Chapter 1. If you are unable to print using the Gprint option, you can print the graphic displays using the DOS command GRAPHICS.COM. To do so follow this procedure:

1. Run GRAPHICS.COM from the DOS directory.
2. Go to the MAP directory and run the AmMap program.
3. Use ⇧ PrtSc to print the selected graphics display.

INPUT FILE

This command prompts the user for an input file name. The user should give the path and name of the desired input file. This command causes the program to:

- Check for the existence of the file. If the file is not found, a warning sound and error message are issued.
- Read and invert the input file. Once the file is located, the program reads the frequency and amplitude values. At the same time the program checks the data for proper format. If invalid data is read, a warning message is displayed. The program then returns to the main menu and ignores all previous data read.
- Normalize input values. All values read from the file are normalized to 1 kHz unless the normalize option is disabled by setting the normalize switch to OFF before issuing the "Input File" command.
- Delete all previous filter calculations.

FIND FILTER COEFFICIENTS

Normally this should be the first command issued by the user. With this command, the program calculates the coefficients of the FIR filter based on the input file. If no input file has been specified, the program calls the "Input file" command and calculates the coefficients and filter response. Otherwise, if an input file has already been read, the program automatically calculates the coefficients and filter response. When the program has the coefficients and filter response, it displays the filter response and error. The error is defined as the sum of the input file and the filter response.

OPTIMIZATION

This command allows for the optimization of the filter response to yield a better compensation for the input file. The user may select up to six frequency bands to add or subtract weights. The weights can be in the form of a step or a slope.

To enter a value in any of the fields, simply type the numbers. You do not need to type the decimal point. The edit keys supported for numerical entry are: ← and Del. The BKSP deletes one digit at a time and Del clears the entire field.

To help the user visualize the shape of the weights added to the signal, the optimization values can be plotted by pressing F5.

For a detailed example on how to use this command, please refer to Example 2 in Chapter 5.

PLOT FILTER RESPONSE

When this menu option is selected, AmMap displays the following plots:

- Desired Filter Response: inverse of the input file
- FIR Filter Response: calculated filter
- Desired and FIR Filter Response (superimposed)
- Error: difference between desired response and FIR filter response. Two horizontal reference lines at 0.5 and –0.5 dB are drawn.

If the Gprint option in enabled, all plots are sent to the printer.

DISPLAY FILTER RESPONSE

This command displays the filter coefficients, filter response, and error. The filter coefficients are shown in both decimal and in the MAP's hex representation. If the hex conversion has not been done, the field for the hex value of the coefficients is left blank.

This command is automatically called by AmMap after the filter coefficients are calculated.

COPY TO DISK FILE

This option stores the results of the program into an output file specified by the user. DOS subdirectories are supported. The information copied onto the output file includes: FIR filter coefficients, desired filter response, FIR filter response, normalized and un-normalized error, input file name, and input file offset.

The basic steps performed by this command are:

- Get output file name
- If the file exists, ask permission to overwrite
- Copy information into disk file.

HEX CONVERSION

Once the filter values are calculated, the use of this command triggers the conversion of the decimal filter coefficients into the MAP's internal hex notation. The file "Coef.Out" is created in the default drive. This file contains all possible signed digit representations for each coefficient. In most cases this file will not be used.

To facilitate the loading of the coefficients into the DSC, the hex representation is shown as LSB followed by MSB.

SHOW SYSTEM RESPONSE

The system response is plotted by invoking this command. The frequency range of the plot generated is from 0–4000 Hz. Frequency samples are every 100 Hz, except for a sample at 50 Hz. This sample is taken to show the transmit path rejection at 60 Hz.

The System Response may be generated as the sum of any combination of the following frequency responses:

- DSC's transmit (HP and LP filters) or receive (LP filter) path
- FIR Filter Response
- Ear/Mic Response (this file is given by the user)

The user can select the desired combination by typing the first letter of the frequency responses or striking the arrow keys. Notice that the receive and transmit paths are mutually exclusive. All items in this sub-menu act like toggle switches.

AmMap prompts the user for an Ear/Mic file if this response is included in the selection. The Ear/Mic file is an ASCII file containing the frequency response of the microphone or earpiece.

CHAPTER 4

INPUT/OUTPUT

INPUT

The inputs to the AmMap program are ASCII files generated by the user. Each line of an input file contains a frequency value followed by an amplitude value in dB. The frequency range is 100–4000 Hz in increments of 100 Hz giving a total of 40 entries. The format is as follows:

Input File Example	
100	–3.1
200	–3.0
.	.
.	.
3900	1.0
4000	1.2

The program checks the file for proper frequency values and valid numeric format. If any of these checks fails, the program stops reading the file and ignores all values previously read from the file.

EAR/MIC FILE

This file contains the frequency response of the earpiece or microphone for which the filter is going to compensate. This file is used to plot the total system response and needs to have inputs for frequencies ranging from 100 Hz to 4000 Hz.

INPUT FILE

This file can be the same Ear/Mic file or a modified version of it. The program bases all coefficient calculations on the inverse of this file so that the sum of the amplitude values in the Input File plus the FIR filter response yields a flat frequency response (0 dB).

Due to the presence of the Low Pass filters in the MAP, the input values used to calculate the X and R filter coefficients are limited to 100–3400 Hz. AmMap has very little or no control over frequencies outside this range.

When the earpiece/microphone response has a fast rolloff, it is desirable to modify this response. The modified version of the earpiece/microphone response is the input file.

Since the X and R filters are not designed to compensate for overall DC gain or loss, the amplitude values read from the input file are normalized to 1 kHz. The value used to normalize is displayed as "offset" in the system plots. The user may disable the normalize option and use these filters to compensate for DC gain or loss as long as the absolute value of all the coefficients generated is below 2.0. Truncation and/or overflow errors may occur.

OUTPUT

AmMap software generates three types of output: Plots, Text Displays, and Disk Files.

PLOTS

Plots are graphic tools to help the user visualize the filter response. Plots can be generated in three different sections of the program:

- Once coefficients have been calculated the following plots may be generated by selecting the "Plot Filter Response" option:

  Desired Response

  FIR Filter Response

  FIR Filter and Desired Response (Overlay)

  Error (difference between desired response and FIR filter response)

- If "Optimization" is selected, the user may plot the optimization values by pressing F5

- The "Show System Response" command gives the user the alternative to plot the sum of any combination of the following signals:

  DSC's transmit (HP and LP filters) or receive path (LP filter)

  FIR Filter (X/R)

  Ear/Mic response

TEXT DISPLAY

Once the coefficients have been calculated, the user may select to display a screen containing the filter coefficients, filter response, normalized error, and hex representation of the filter coefficients. The filter coefficients are shown in decimal and in hex (after coefficient conversion).

FILES

Two ASCII files may be generated by AmMap: the Output and the "Coef.Out" files.

The Output File is an ASCII file containing the program results. It includes the FIR filter coefficients, desired response, normalized and unnormalized error, input file name, and input file offset.

This file is created at the user's request and copied into a disk file specified by the user at run time. If the user attempts to write into an existing file, a warning tone and message are issued. The user is then allowed to abort the operation.

The "Coef.out" file is generated by the program after the hex conversion of the coefficients is completed. This file contains all possible hexadecimal representations of a coefficient using the MAP's signed digit. In most cases this file will not be used.

CHAPTER 5

AmMap EXAMPLES

This section contains sample sessions with the AmMap software. The files "Map1.In," "Map2.In," and "Map22.In" are used for the examples. Please make sure AmMap is properly installed in your computer before running these sessions.

Note: The plots generated by AmMap may vary in appearance, depending on the graphics adapter used. The following plots were generated on a Compaq Deskpro™ with an EGA card.

EXAMPLE 1

This example demonstrates the basic procedures involved in using AmMap. The objective is to calculate the X filter coefficients necessary to compensate for the Ear-piece acoustic response stored in the file "Map1.In."

RUN AmMap PROGRAM

Once you have selected the proper disk drive and directory, you are ready to run AmMap. At the DOS prompt, type:

```
AmMap ↵
```

The start up screen with the AMD logo is displayed. Press any key to continue.

A second screen containing a welcome message is displayed. Press Spacebar to continue.

FIND FILTER COEFFICIENTS

Now you are placed at the Main Menu. The option "Find Filter Coefficients" is highlighted, and at the bottom of the screen the normalize flag is highlighted too.

Press ↵ to select "Find Filter Coefficients."

Since no input file has been previously selected, the system will prompt the user for an input file name. Type:

```
MAP1.IN ↵
```

For text entry all edit keys are supported.

DISPLAY FILTER RESPONSE

After the program calculates the filter coefficients and response, it displays the results on the terminal screen. This screen contains the decimal value of the coefficient, the filter response in dB and the error in dB with respect to the input signal. Notice that the field for the hex representation of the coefficients is left blank until the hex conversion is done. The normalized error appears to be reasonably small as shown in Figure 5-1.

Figure 5-1 **Filter Response (Normalized Error)**

Coef 1	1.00499108 →	Coef 5	0.06763127 →
Coef 2	0.08505275 →	Coef 6	0.00213335 →
Coef 3	0.18789355 →	Coef 7	-0.00486192 →
Coef 4	0.00955288 →	Coef 8	0.00528762 →

Freq	Filter Resp.	error	Freq	Filter Resp.	error
100	2.62259	-0.09229	1800	-0.97257	-0.18745
200	2.52371	-0.29118	1900	-0.97247	-0.23736
300	2.36283	-0.05205	2000	-0.98757	-0.30245
400	2.14578	-0.06911	2100	-1.03102	-0.16591
500	1.88045	-0.13444	2200	-1.10873	-0.14362
600	1.57658	-0.13830	2300	-1.21731	-0.13219
700	1.24542	0.03053	2400	-1.34278	-0.25767
800	0.89931	0.18443	2500	-1.46084	-0.27572
900	0.55133	0.13644	2600	-1.53975	-0.25464
1000	0.21489	0.00000	2700	-1.54718	-0.11207
1100	-0.09669	0.18843	2800	-1.45986	-0.17474
1200	-0.37083	0.01428	2900	-1.27212	-0.18701
1300	-0.59691	-0.16179	3000	-0.99819	-0.01308
1400	-0.76792	-0.28281	3100	-0.66671	-0.08160
1500	-0.88240	-0.09729	3200	-0.31134	-0.22622
1600	-0.94573	-0.01062	3300	0.03747	-0.07742
1700	-0.97006	0.01506	3400	0.35681	-0.05807

Space Key - To Return Normalized Error

To check the unnormalized error:

Return to the Main Menu and set the Normalize switch OFF, by pressing N.

Press D to select the Display Filter Response command, then press ↵.

The error values displayed on the screen are not Normalized. Notice that at 1 kHz, the error is 0.21489 dB as shown in Figure 5-2.

Figure 5-2 Filter Response (Unnormalized Error)

Coef 1	1.00499108 →	Coef 5	0.06763127 →
Coef 2	0.08505275 →	Coef 6	0.00213335 →
Coef 3	0.18789355 →	Coef 7	-0.00486192 →
Coef 4	0.00955288 →	Coef 8	0.00528762 →

Freq	Filter Resp.	error	Freq	Filter Resp.	error
100	2.62259	0.12259	1800	-0.97257	0.02743
200	2.52371	-0.07629	1900	-0.97247	-0.02247
300	2.36283	0.16283	2000	-0.98757	-0.08757
400	2.14578	0.14578	2100	-1.03102	0.04898
500	1.88045	0.08045	2200	-1.10873	0.07127
600	1.57658	0.07658	2300	-1.21731	0.08269
700	1.24542	0.24542	2400	-1.34278	-0.04278
800	0.89931	0.39931	2500	-1.46084	-0.06084
900	0.55133	0.35133	2600	-1.53975	-0.03975
1000	0.21489	0.21489	2700	-1.54718	0.10282
1100	-0.09669	0.40331	2800	-1.45986	0.04014
1200	-0.37083	0.22917	2900	-1.27212	0.02788
1300	-0.59691	0.05309	3000	-0.99819	0.20181
1400	-0.76792	-0.06792	3100	-0.66671	0.13329
1500	-0.88240	0.11760	3200	-0.31134	-0.01134
1600	-0.94573	0.20427	3300	0.03747	0.13747
1700	-0.97006	0.22994	3400	0.35681	0.15681

Space Key - To Return

PLOT FILTER RESPONSE

Return to the Main Menu by pressing Spacebar. Select the command "Plot Filter Response." The most helpful plot is the error plot.

Return to the Main Menu and set the Normalize switch back to ON and reissue the Plot command. Note that the normalized error is significantly below the horizontal axes drawn at –0.5 dB and +0.5 dB (Figure 5-3d).

HEX CONVERSION

Assuming the normalized error is acceptable, we proceed to convert the filter coefficients by selecting the "Hex Conversion" command in the Main Menu.

Figure 5-3 Plots Generated by "Plot Filter Response," Map1.In

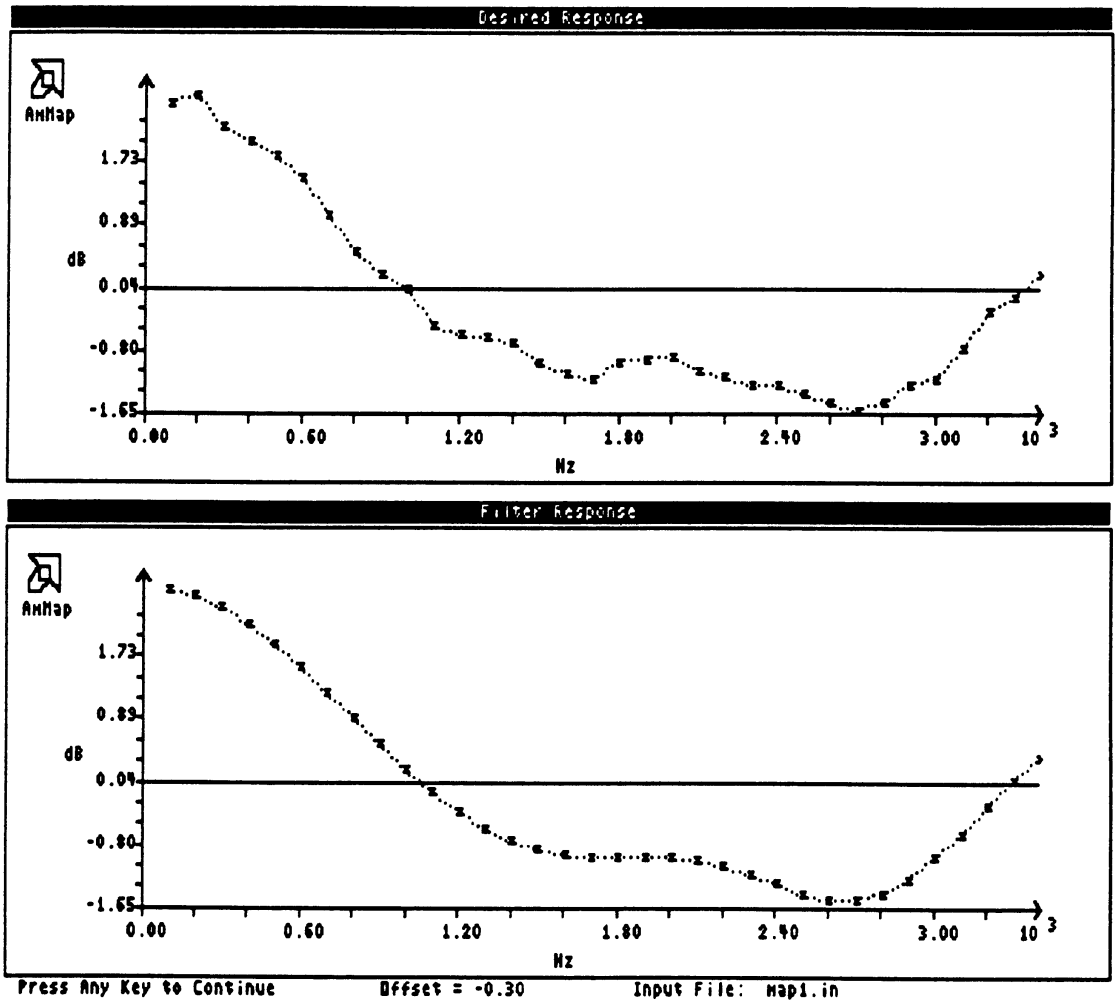
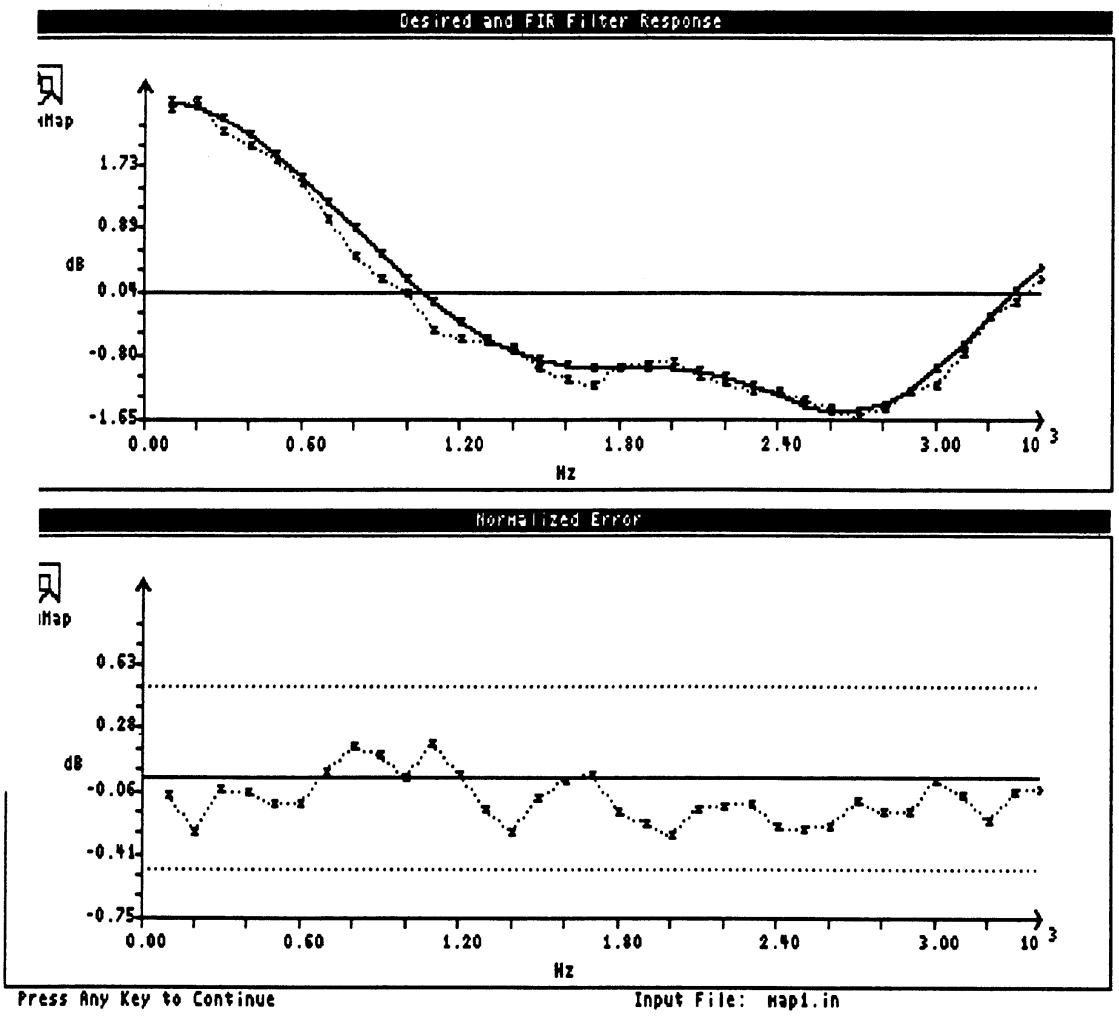


Figure 5-3 Plots Generated by "Plot Filter Response," Map1.In (continued)



Once the conversion is completed, the hexadecimal representation of the coefficients is displayed on the screen as LSB MSB (Figure 5-4). When the "Display Filter Response" is issued, the hex representation for a coefficient is now displayed after its decimal value (Figure 5-5).

SHOW SYSTEM RESPONSE

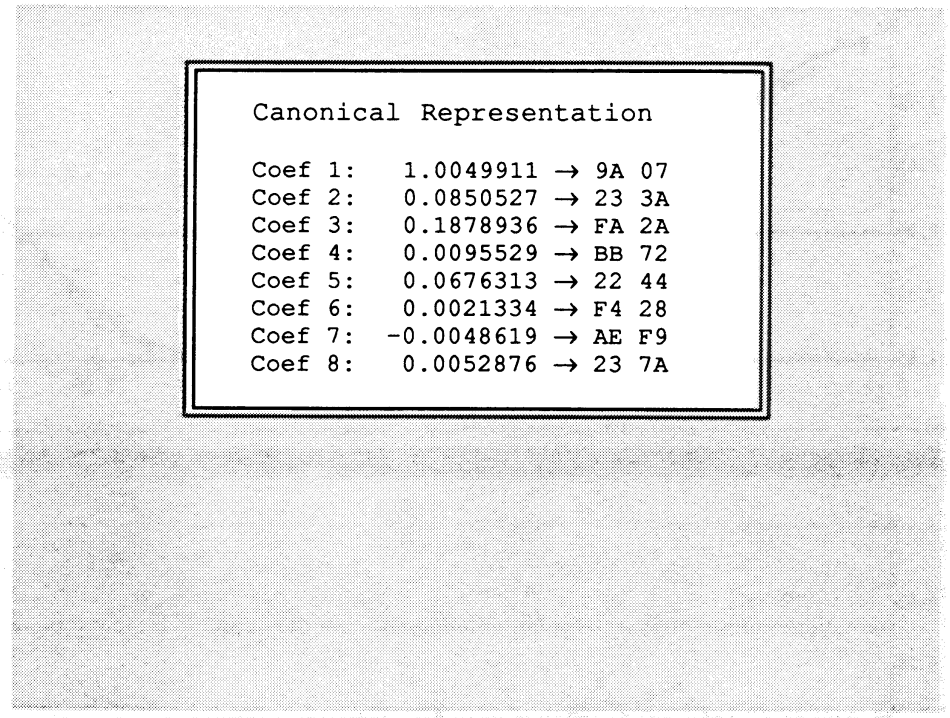
Select the "Show System Response" command. You may select any combination of the frequency responses listed in the sub-menu. To select or unselect (toggle) any of them, you may use the first letter of the desired frequency responses or the ⊡ and ⊡. The items selected are highlighted. Following are some examples:

- To see the Input File, select "Ear/Mic" by typing : `E`, then press ⊡ and give the input file name:

  `MAP1.IN` ⊡

The contents of the screen should resemble Figure 5-6.

Figure 5-4 Hex Representation of the Coefficients, Map1.In



- To plot the filter response plus the input file, type `F` ↵. Notice that both "Ear/Mic" and "Filter (X/R)" are now highlighted. Press ↵ to use the displayed file name (Figure 5-7).
- To view the entire system response on the transmit path, type: `X`. Three items should appear highlighted; press ↵ (Figure 5-8).
- Now if you want to see just the filter response, you may unselect:
  "Ear/Mic" by pressing: `E`
  "Xmit Path" by pressing: `X`

Then press ↵.

To make a hard copy of any of the plots, set the Gprint option to ON by typing `G` in the Main Menu or in the Show System Response sub-menu.

COPY TO DISK FILE

Now save the designed filter parameters into a disk file. Select the "Copy to Disk File" option and type in the name of the output file. For example, type:

`Map1.OUT` ↵

You may continue the sample session with Example 2 or leave the program by pressing F9.

Figure 5-5 **Filter Response with Hex Values, Map1.In**

Coef 1	1.00499108 → 9A 07	Coef 5	0.06763127 → 22 44
Coef 2	0.08505275 → 23 3A	Coef 6	0.00213335 → F4 28
Coef 3	0.18789355 → FA 2A	Coef 7	-0.00486192 → AE F9
Coef 4	0.00955288 → BB 72	Coef 8	0.00528762 → 23 7A

Freq	Filter Resp.	error	Freq	Filter Resp.	error
100	2.62259	-0.09229	1800	-0.97257	-0.18745
200	2.52371	-0.29118	1900	-0.97247	-0.23736
300	2.36283	-0.05205	2000	-0.98757	-0.30245
400	2.14578	-0.06911	2100	-1.03102	0.16591
500	1.88045	-0.13444	2200	-1.10873	0.14362
600	1.57658	-0.13830	2300	-1.21731	0.13219
700	1.24542	0.03053	2400	-1.34278	-0.25767
800	0.89931	0.18443	2500	-1.46084	-0.27572
900	0.55133	0.13644	2600	-1.53975	-0.25464
1000	0.21489	0.00000	2700	-1.54718	-0.11207
1100	-0.09669	0.18843	2800	-1.45986	0.17474
1200	-0.37083	0.01428	2900	-1.27212	0.18701
1300	-0.59691	-0.16179	3000	-0.99819	0.01308
1400	-0.76792	-0.28281	3100	-0.66671	0.08160
1500	-0.88240	-0.09729	3200	-0.31134	-0.22622
1600	-0.94573	-0.01062	3300	0.03747	0.07742
1700	-0.97006	0.01506	3400	0.35681	0.05807

Space Key - To Return Normalized Error

EXAMPLE 2

The purpose of this example is to show the use of an input file that is different from the Earpiece/Microphone response and to explain the filter optimization process. The microphone response stored in the file "Map2.In" is used as the Ear/Mic file.

The frequency response (Ear/Mic) stored in "Map2.In" has a fast rolloff at lower frequencies (Figure 5-9). Therefore, it is desirable to modify this file in order to calculate a filter to compensate for the dip at approximately 2 kHz. Table 5-1 depicts the changes to the microphone response file.

A modified version of this Ear/Mic file is stored in the "Map22.In" file.

If you are starting a new session, run the AmMap program. To run it, at the DOS prompt type:

`AMMAP` ↵ followed by [Spacebar] [Spacebar].

INPUT FILE

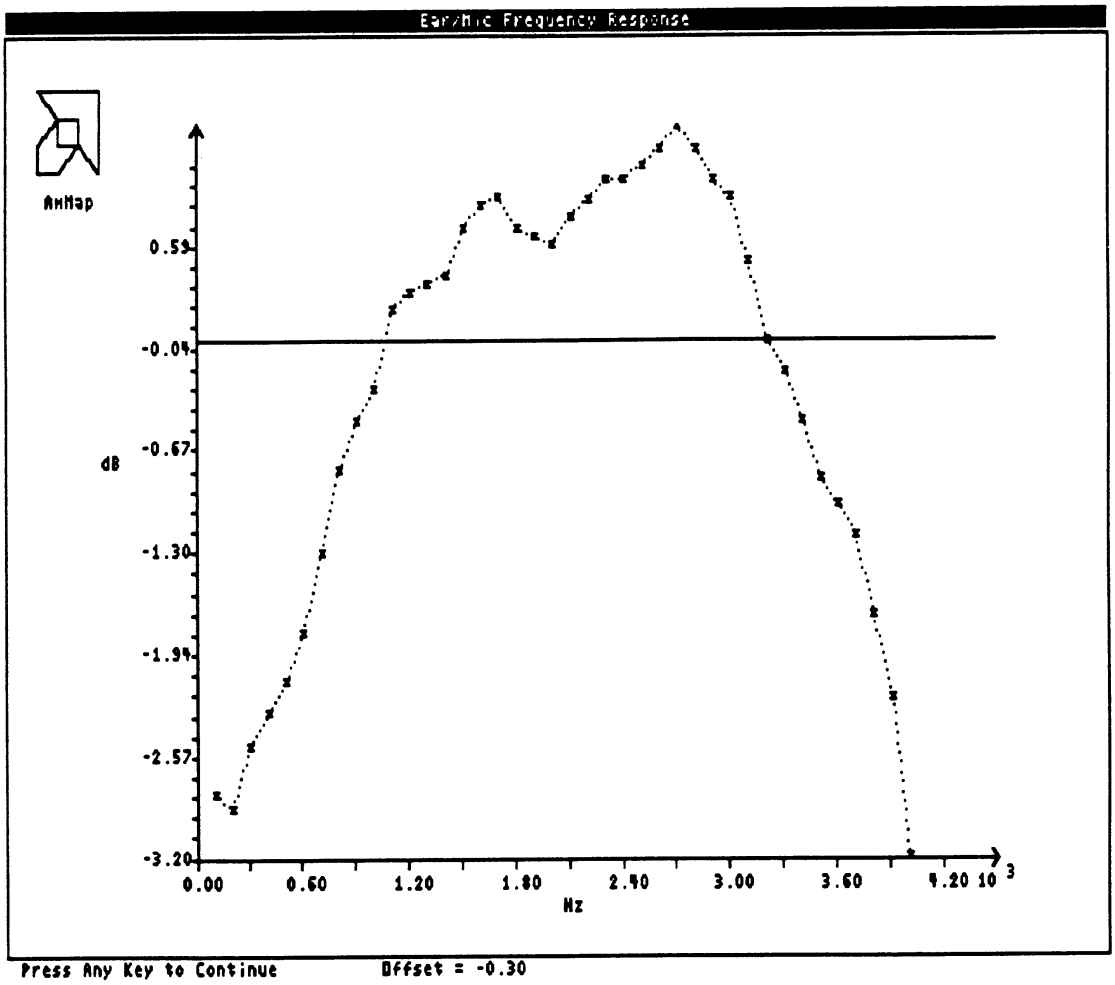
To enter the new input file, select the "Input file" option by typing: `I` ↵. Then enter the modified file's name:

`MAP22.IN` ↵

Notice that once the program reads the contents of the new file, it resets all previously calculated parameters. Try using the Display or Plot commands.

If you want to see the difference between the earpiece response and the modified version of it, use the "Show System Response" option.

Figure 5-6 **Earpiece Response, Input File Map1.In**



- To see the original microphone response (Figure 5-9) follow these steps:
  1. Select the Show System Response option from the Main Menu.
  2. Select Ear/Mic option in the system response sub-menu.
  3. At the Ear/Mic file prompt, enter:

     `MAP2.IN` ↵

- Now to see the modified earpice response (Figure 5-10), follow these steps:
  1. Select Ear/Mic option in the system response sub-menu.
  2. At the Ear/Mic file prompt, enter:

     `MAP22.IN` ↵

Notice the difference between the vertical scales.

Figure 5-7 **R Filter Plus Earpiece Response, Map1.In**

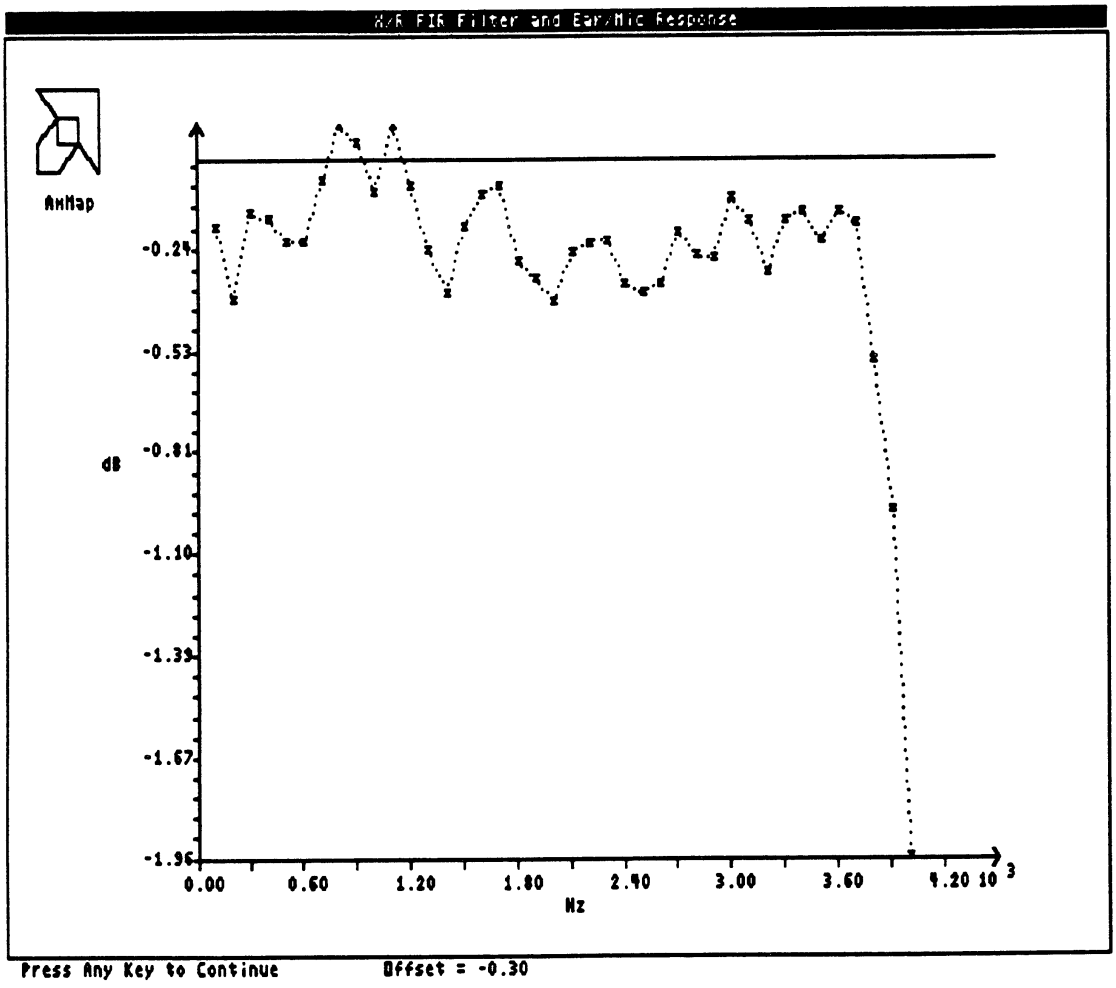


Figure 5-8 Total System Response

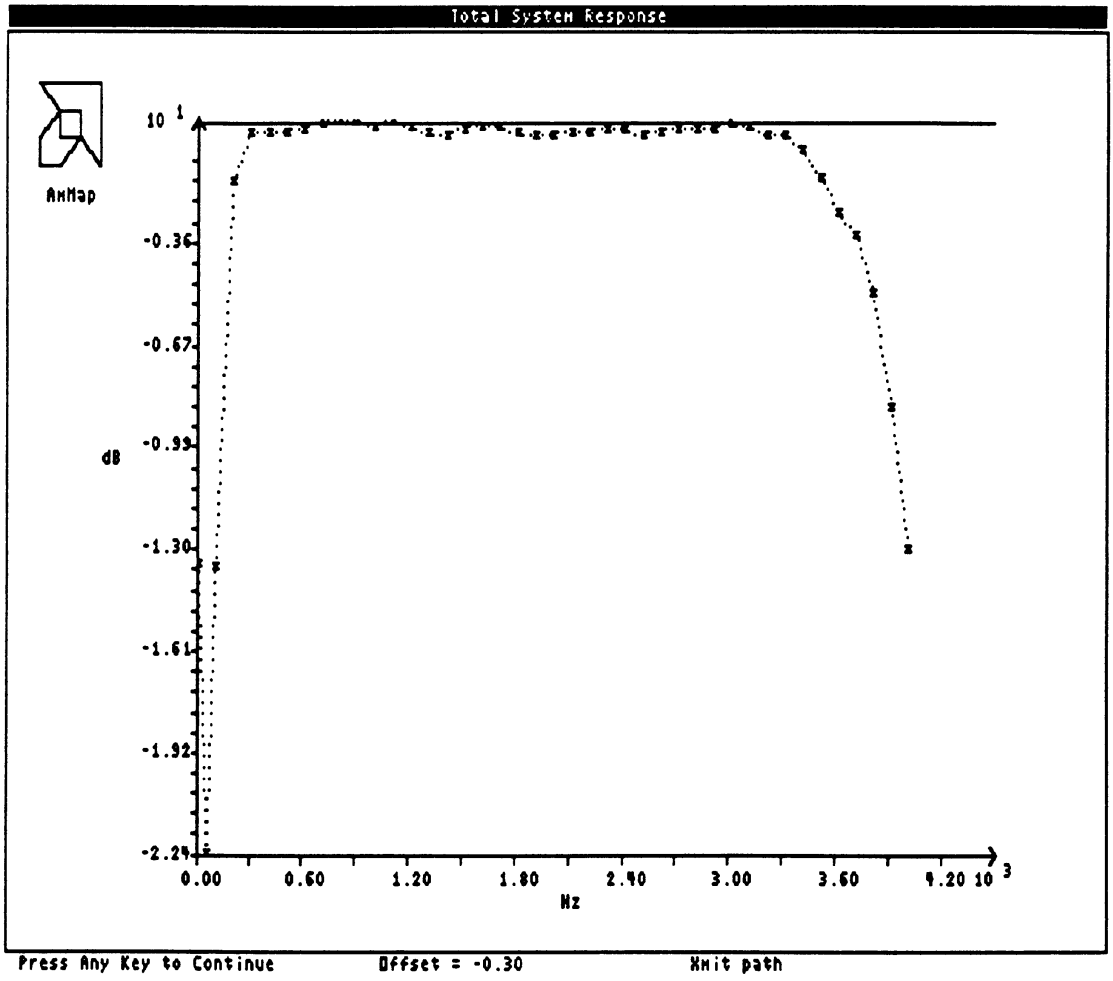


Table 5-1 **Changes to the Original Microphone Response File**

Frequency	Original	Modified	
100	5	17	
200	11	17	
300	15	17	
400	17.4	17.4	Unchanged

Figure 5-9 **Original Microphone Response, Map1.In**

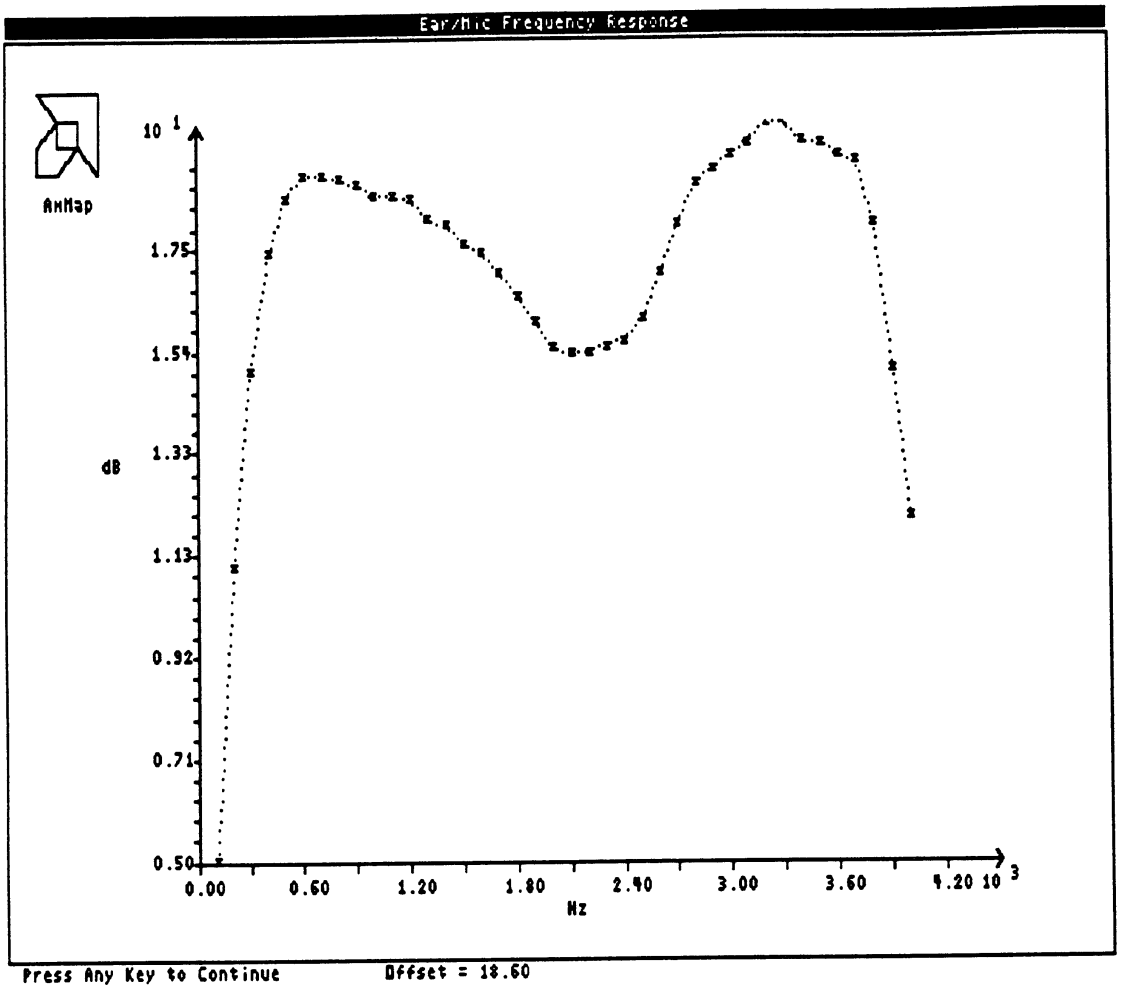
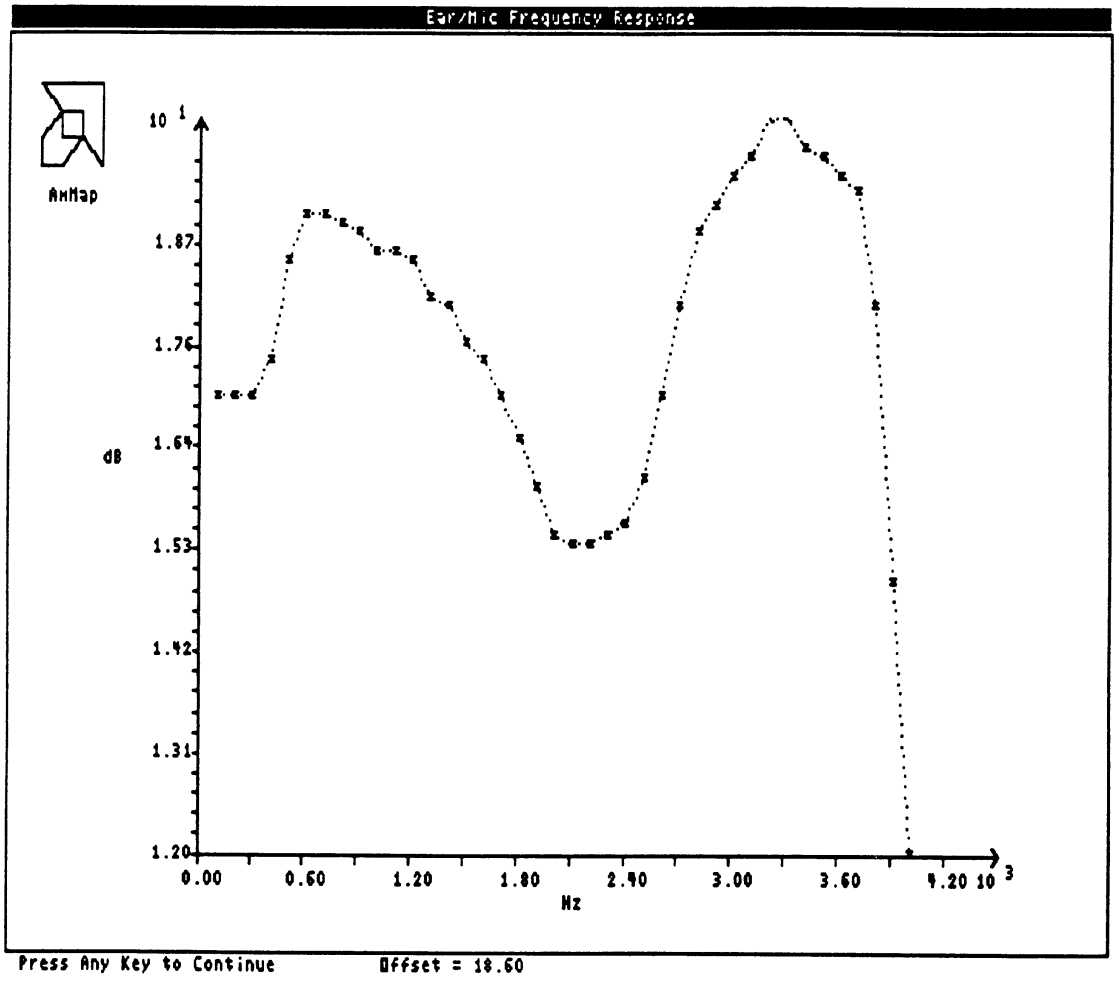


Figure 5-10 Modified Input File, Map22.In



FIND FILTER COEFFICIENTS AND PLOT FILTER RESPONSE

From the Main Menu, press: F ↵

By looking at the displayed error values (Figure 5-11) an error of 0.97 dB at 2800 Hz can be seen. This indicates that the filter response needs to be optimized.

To plot the filter response follow these steps:

1. Press Spacebar to return to the Main Menu.
2. To select the Plot option type: P ↵.

Select the second group of plots. On the "Desired and FIR Filter Response" plot we can see that to better match the desired response, the filter needs to have a sharper slope in the 2500–2800 Hz range (Figure 5-12).

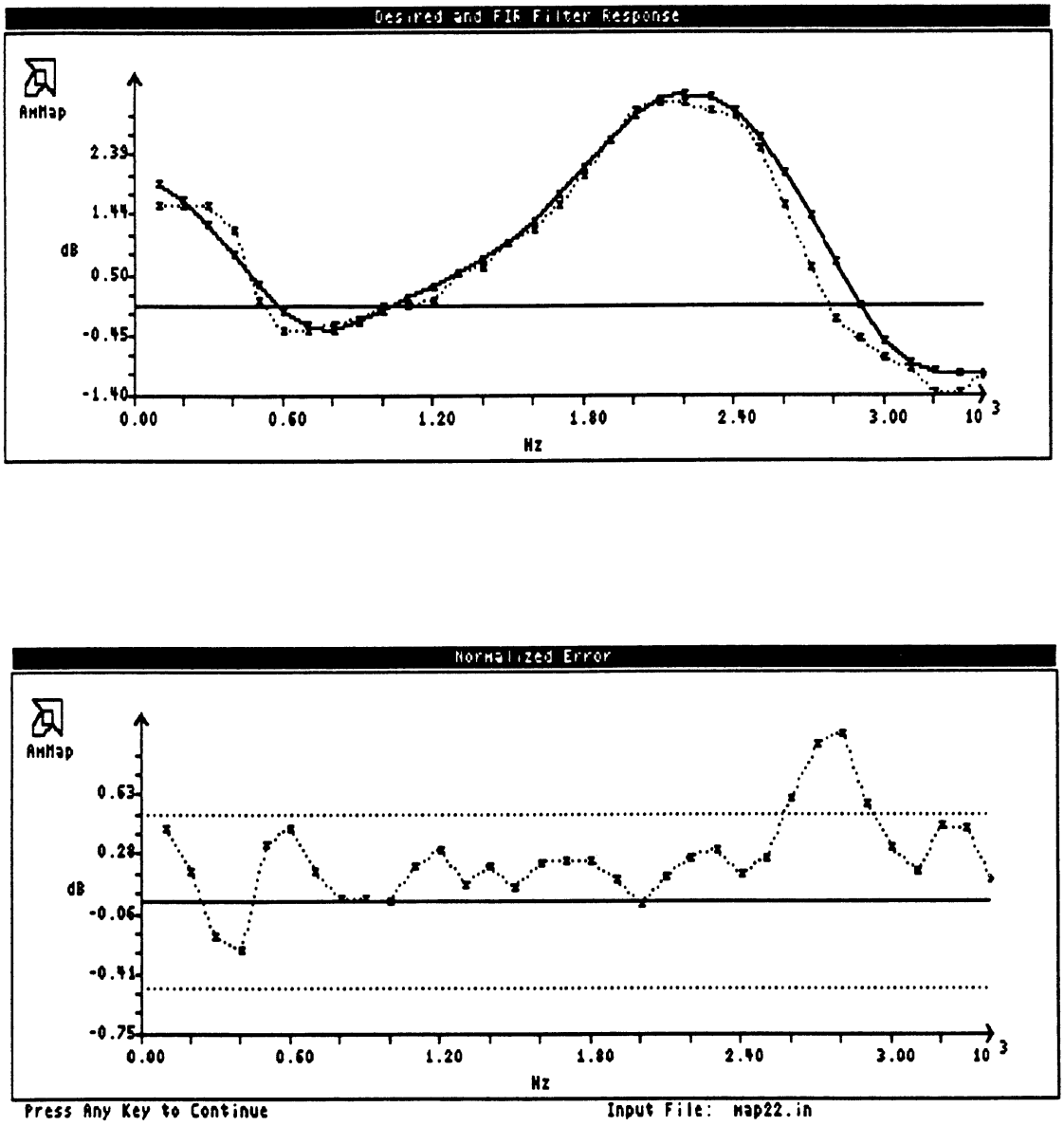
Figure 5-11 **Initial Filter Response**

Coef 1	1.07663571 →	Coef 5	0.13941070 →
Coef 2	0.09583821 →	Coef 6	-0.01845170 →
Coef 3	-0.18707148 →	Coef 7	-0.00595045 →
Coef 4	0.10317546 →	Coef 8	0.05822703 →

Freq	Filter Resp.	error	Freq	Filter Resp.	error
100	1.93381	0.43310	1800	2.19087	0.24015
200	1.68386	0.18315	1900	2.62723	0.12651
300	1.29681	-0.20390	2000	2.99405	-0.00666
400	0.82229	-0.27842	2100	3.24740	0.14668
500	0.33524	0.33452	2200	3.35559	0.25488
600	-0.07279	0.42650	2300	3.29860	0.29788
700	-0.32199	0.17730	2400	3.06689	0.16618
800	-0.38186	0.01742	2500	2.66193	0.26122
900	-0.28472	0.01457	2600	2.09936	0.59864
1000	-0.09929	0.00000	2700	1.41554	0.91482
1100	0.11027	0.20956	2800	0.67560	0.97489
1200	0.31001	0.30930	2900	-0.02476	0.57453
1300	0.50124	0.10052	3000	-0.57913	0.32015
1400	0.71163	0.21091	3100	-0.91836	0.18093
1500	0.97745	0.07674	3200	-1.05419	0.44509
1600	1.32171	0.22099	3300	-1.07059	0.42870
1700	1.73818	0.23746	3400	-1.07124	0.12804

Space Key - To Return Normalized Error

Figure 5-12 Desired Response and Filter Response, Normalized Error



OPTIMIZATION

Return to the Main Menu and select the optimization option. Type: o ↵ followed by:

- In the range 2500 to 2800, give a slope of –2.0.
- Press F10 to save the value and return to the Main Menu.
- Calculate Filter Coefficients and examine the error plot.
- Return to the optimization procedure.
- Provide a step of –0.6 for the range 3200–3300 Hz (notice that the previous optimization slope is still present—Figure 5-13).
- Calculate the filter coefficients. In the displayed screen (Figure 5-14) notice that the maximum error value is –0.39 at 400 Hz. (Since we modified the first three samples of the earpiece response, the error values below 400 Hz can be ignored.)
- Plot the filter response (Figure 5-15).

Figure 5-13 Filter Optimization Screen

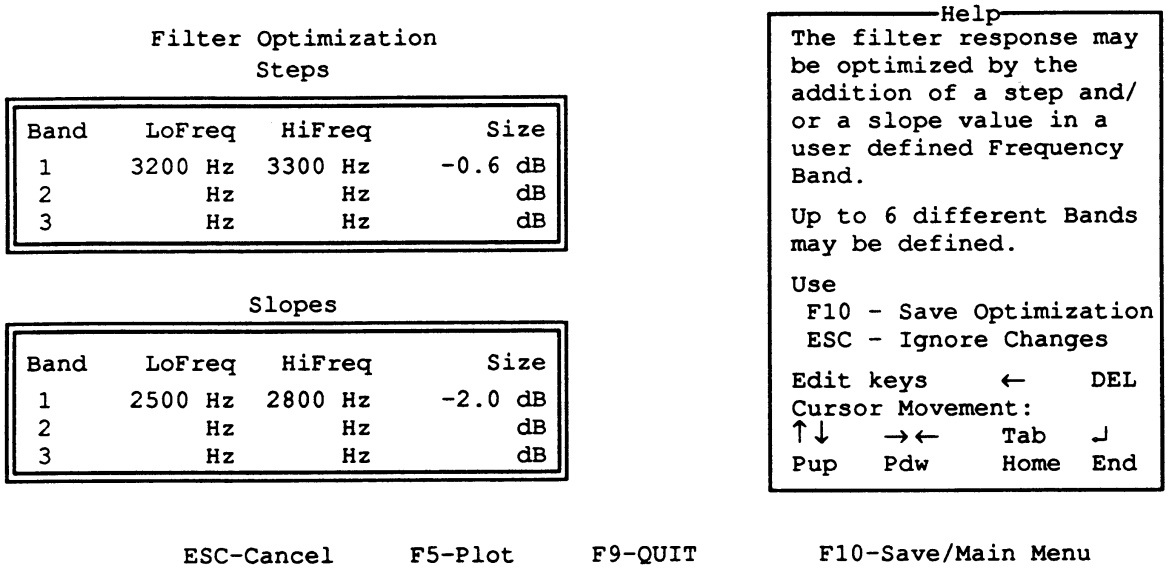


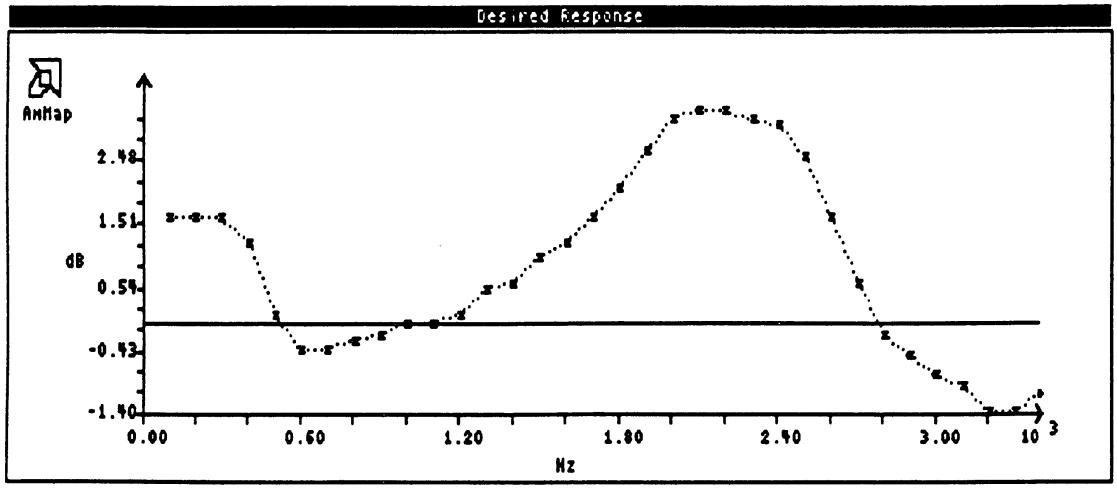
Figure 5-14 Optimized Filter Response

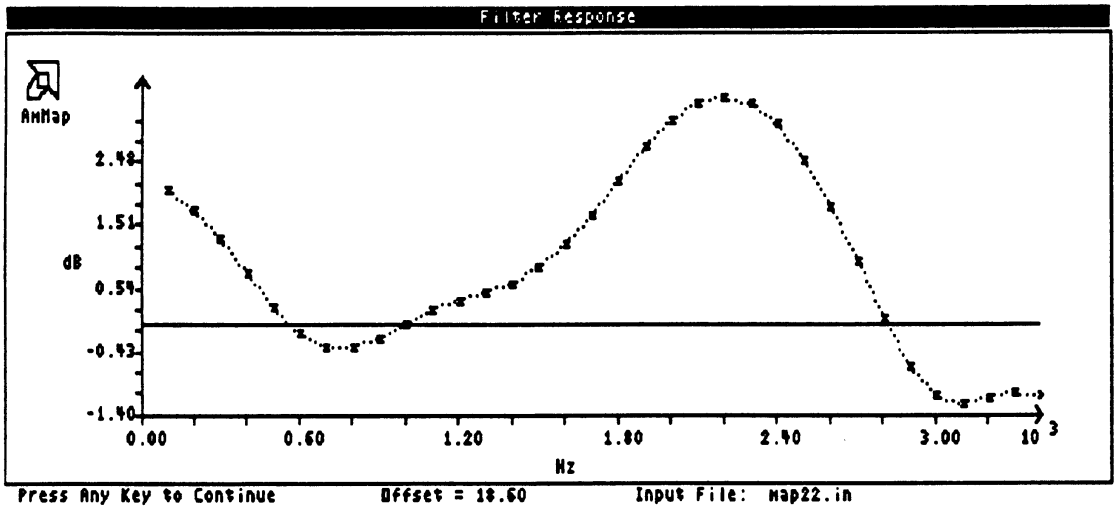
Coef 1	1.04225502 →	Coef 5	0.12992657 →
Coef 2	0.15323995 →	Coef 6	0.00688662 →
Coef 3	-0.21665301 →	Coef 7	-0.03933457 →
Coef 4	0.11405010 →	Coef 8	0.08678548 →

Freq	Filter Resp.	error	Freq	Filter Resp.	error
100	2.02838	0.44552	1800	2.18656	0.15369
200	1.74835	0.16549	1900	2.68758	0.10472
300	1.31582	-0.26704	2000	3.09912	0.01626
400	0.78993	-0.39294	2100	3.36790	0.18503
500	0.26199	0.17913	2200	3.45799	0.27513
600	-0.15687	0.26027	2300	3.34754	0.26468
700	-0.37715	0.03999	2400	3.02641	0.04355
800	-0.38097	-0.06383	2500	2.49738	0.01452
900	-0.22956	-0.01242	2600	1.78289	0.20003
1000	-0.01714	0.00000	2700	0.93900	0.35614
1100	0.18159	0.19873	2800	0.07291	0.29005
1200	0.33654	0.25368	2900	-0.65739	-0.14026
1300	0.46380	-0.01906	3000	-1.10231	-0.28518
1400	0.61373	0.03086	3100	-1.22804	-0.21090
1500	0.84692	-0.13594	3200	-1.15247	0.26467
1600	1.20105	0.01819	3300	-1.05857	0.35857
1700	1.66601	0.08315	3400	-1.10089	0.01625

Space Key - To Return Normalized Error

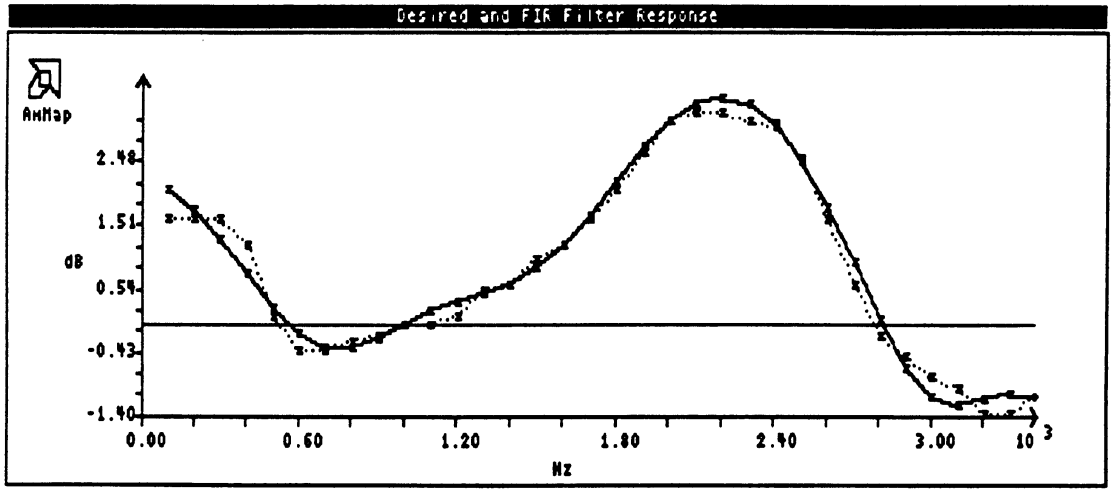
Figure 5-15 Optimized Filter Plots

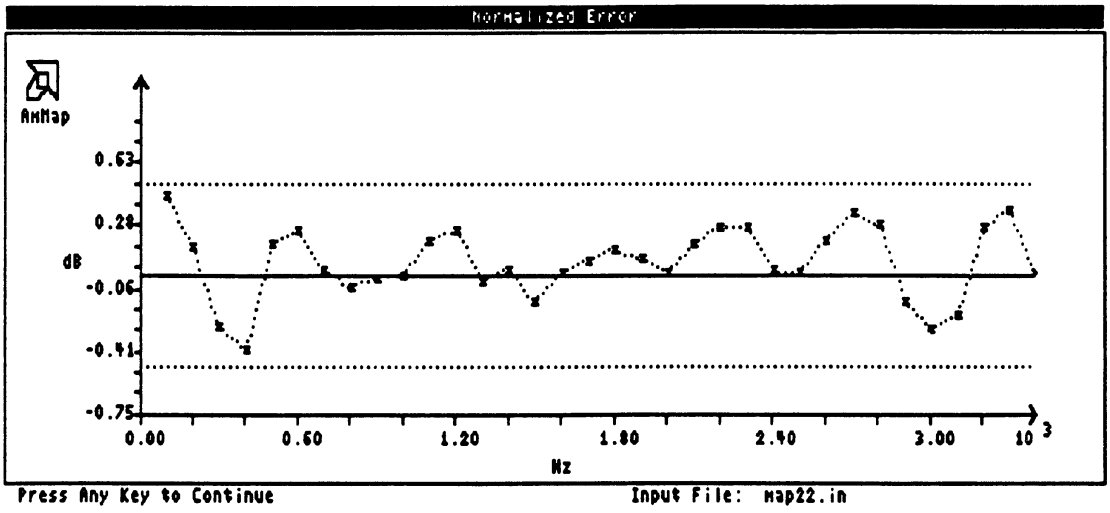




Press Any Key to Continue Offset = 18.60 Input File: map22.in

Figure 5-15 Optimized Filter Plots (continued)





HEX CONVERSION AND COPY TO DISK FILE

Optimization is now completed. You may want to try other optimization values to get a better feel for the optimization procedure.

Right now we are ready to convert the decimal coefficients into the MAP's signed digit representation. Select the "Hex Conversion" command. After a couple of minutes you will see a display with the hexadecimal values (Figure 5-16).

Copy the results to an output file. From the Main Menu select the "Copy to Disk File" option. At the file name prompt enter:

```
MAP2.OUT ↵
```

A printed copy of the output file can be found in Figure 5-17.

SHOW SYSTEM RESPONSE

Select the "Show System Response" command to generate the following plots:

- Earpiece response on the receive path of the MAP without the X/R filter (Figure 5-18).
- Sum of the designed R filter with the earpiece response (Figure 5-19).
- The total system response. This is the sum of the earpiece response, R filter response and MAP's receive path (Figure 5-20).

Note: Be sure to change the Ear/Mic file name to Map2.in.

Figure 5-16 Hex Representation of the Coefficients

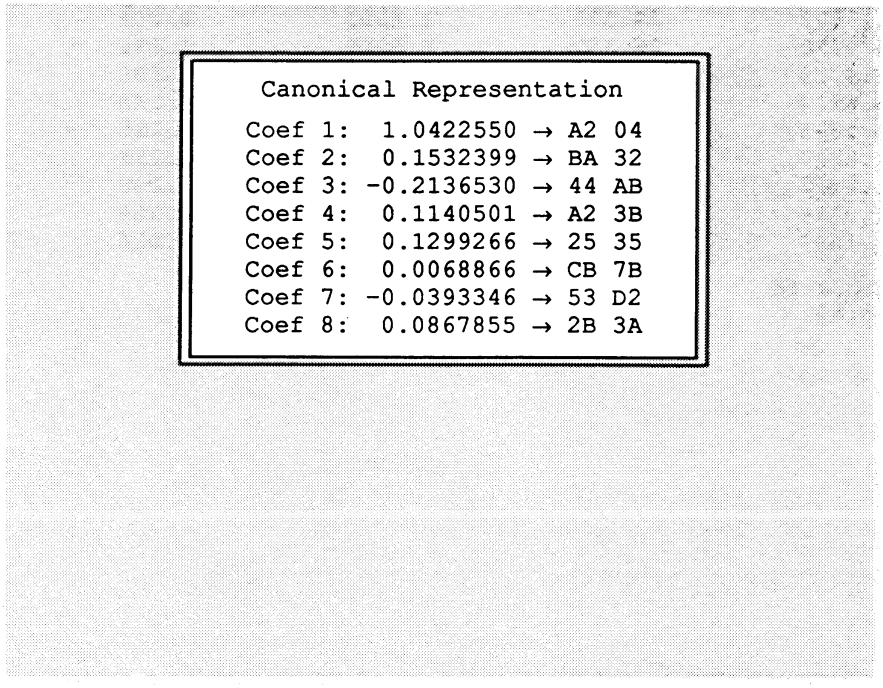


Figure 5-17 Listing of the File Map2.Out

AmMap Program

FIR Filter Coefficients

1	1.04225502	A2	04	5	0.12992657	25	35
2	0.15323995	BA	32	6	0.00688662	CB	7B
3	-0.21665301	44	AB	7	-0.03933457	53	D2
4	0.11405010	A2	3B	8	0.08678548	2B	3A

Freq.	FIR Filter		Input	Error	
(Hz)	Mag (dB)	Phase (Deg)	Mag (dB)	Normalized (dB)	UnNorm (dB)
100	2.0284	3.406	1.6000	0.446	0.428
200	1.7483	6.363	1.6000	0.165	0.148
300	1.3158	8.432	1.6000	-0.267	-0.284
400	0.7899	9.223	1.2000	-0.393	-0.410
500	0.2620	8.509	0.1000	0.179	0.162
600	-0.1569	6.410	-0.4000	0.260	0.243
700	-0.3772	3.489	-0.4000	0.040	0.023
800	-0.3810	0.565	-0.3000	-0.064	-0.081
900	-0.2296	-1.709	-0.2000	-0.012	-0.030
1000	-0.0171	-3.133	0.0000	0.000	-0.017
1100	0.1816	-3.908	0.0000	0.199	0.182
1200	0.3365	-4.422	0.1000	0.254	0.237
1300	0.4638	-5.045	0.5000	-0.019	-0.036
1400	0.6137	-5.961	0.6000	0.031	0.014
1500	0.8469	-7.058	1.0000	-0.136	-0.153
1600	1.2011	-7.939	1.2000	0.018	0.001
1700	1.6660	-8.095	1.6000	0.083	0.066
1800	2.1866	-7.143	2.0500	0.154	0.137
1900	2.6876	-4.954	2.6000	0.105	0.088
2000	3.0991	-1.633	3.1000	0.016	-0.001
2100	3.3679	2.572	3.2000	0.185	0.168
2200	3.4580	7.344	3.2000	0.275	0.258
2300	3.3475	12.334	3.1000	0.265	0.248
2400	3.0264	17.160	3.0000	0.044	0.026
2500	2.4974	21.399	2.5000	0.015	-0.003
2600	1.7829	24.570	1.6000	0.200	0.183
2700	0.9390	26.161	0.6000	0.356	0.339
2800	0.0729	25.771	-0.2000	0.290	0.273
2900	-0.6574	23.426	-0.5000	-0.140	-0.157
3000	-1.1023	19.919	-0.8000	-0.285	-0.302
3100	-1.2280	16.635	-1.0000	-0.211	-0.228
3200	-1.1525	14.723	-1.4000	0.265	0.248
3300	-1.0586	14.511	-1.4000	0.359	0.341
3400	-1.1009	15.631	-1.1000	0.016	-0.001

Input file : map22.in
Offset : 18.60

Figure 5-18 **Microphone and MAP without X/R Filter**

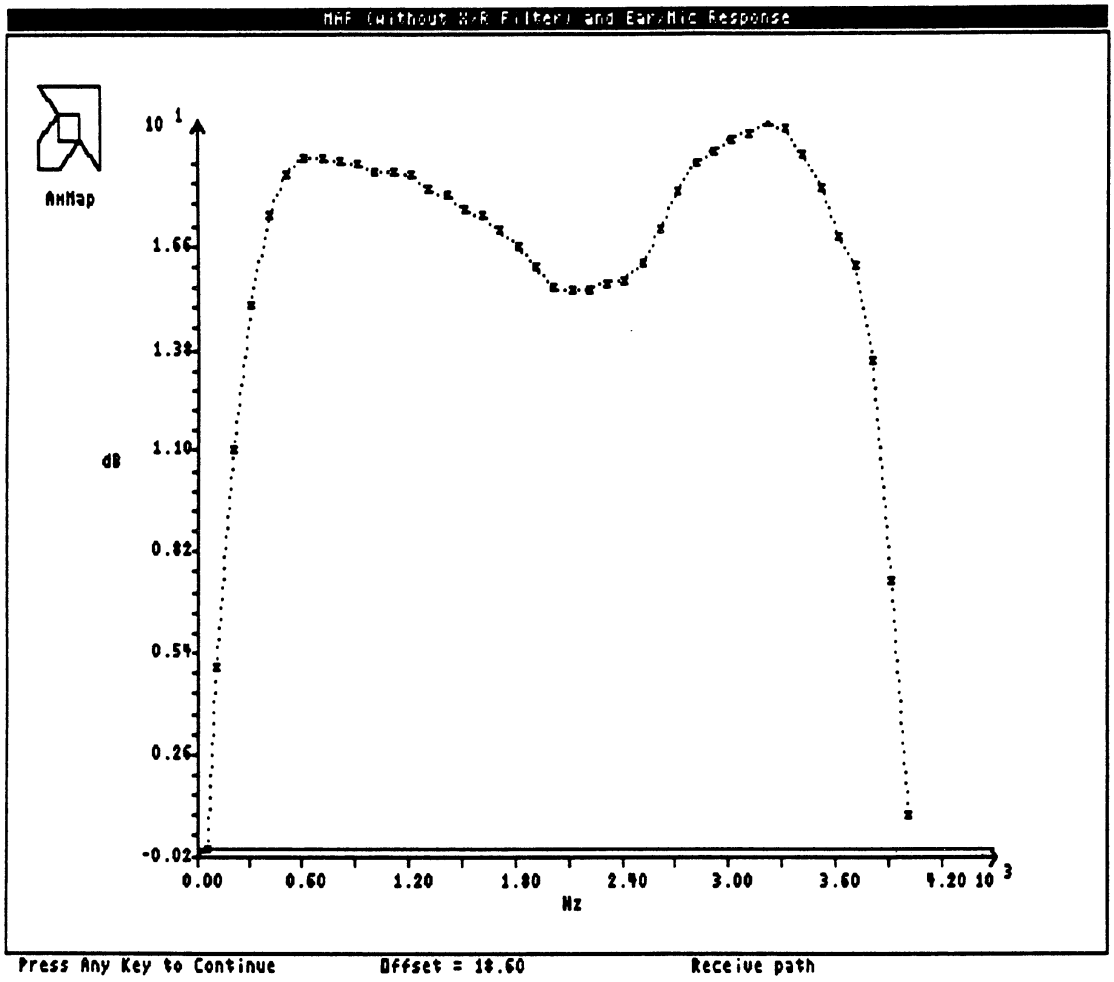


Figure 5-19 R Filter and Microphone

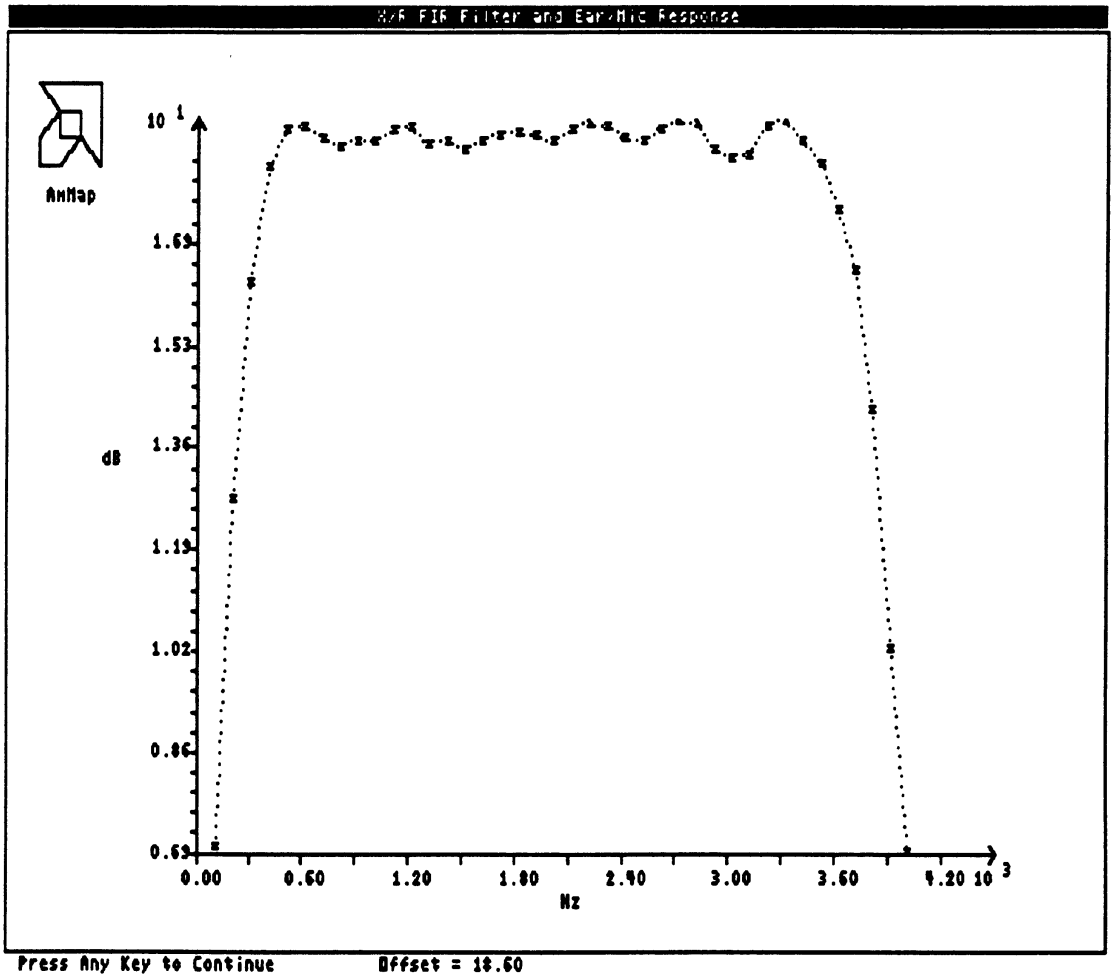
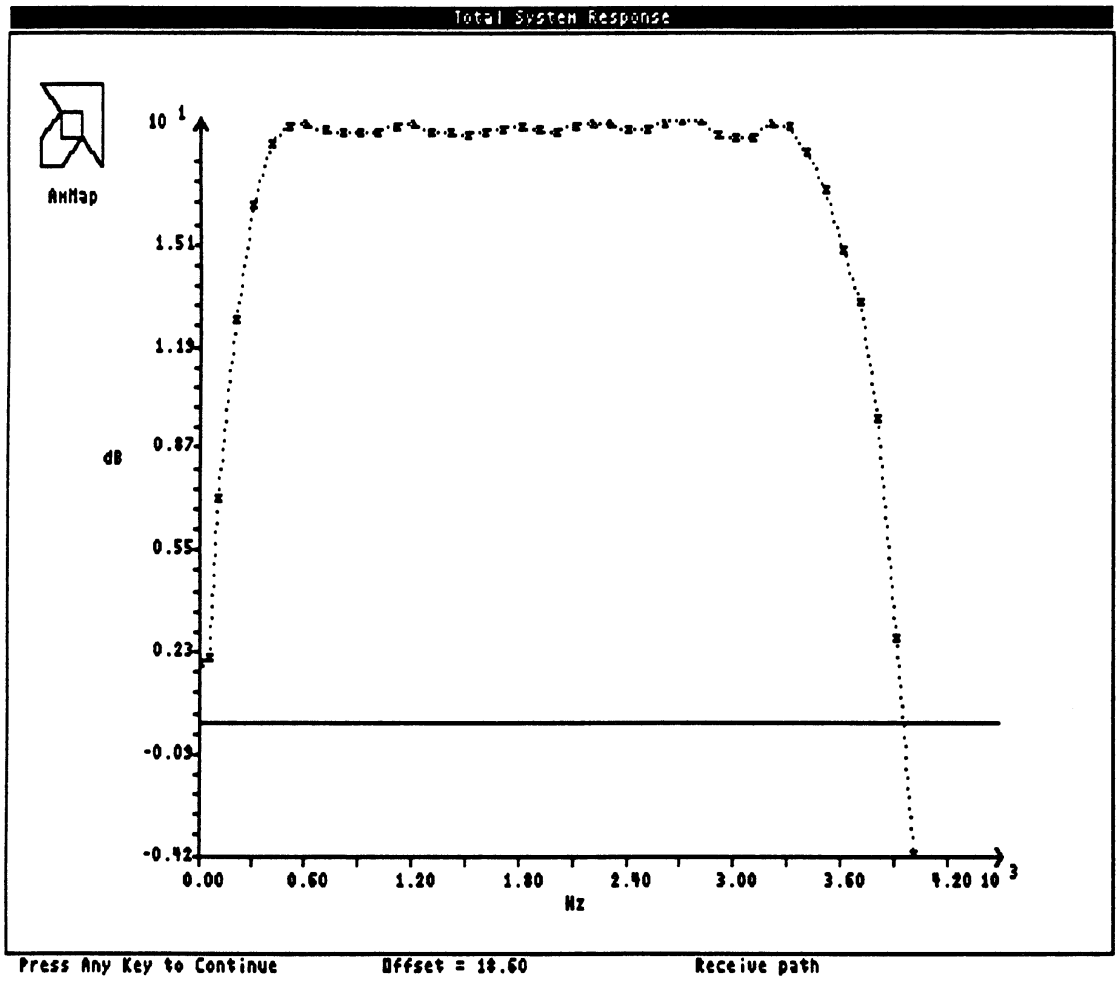


Figure 5-20 Total System Response with Optimized Filter



APPENDIX A

X AND R FILTERS (Am79C30A MAIN AUDIO PROCESSOR)

The Main Audio Processor (MAP) in the Am79C30A uses Digital Signal Processing techniques to implement the CODEC and filter functions. In the receive and transmit path, the MAP's user programmable filters allow the user to alter the frequency response. These programmable filters provide frequency compensation and gain control. The X and R filters are frequency response correction filters used to compensate for the microphone, loudspeaker, or earpiece frequency responses.

There is one frequency compensation filter in the transmit path (X filter) and one in the receive path (R filter). The X and R filters are user-programmable 8-tap Finite Impulse Response (FIR) filters.

The X filter is an attenuation distortion correction filter which modifies the frequency response in the transmit path to compensate for the characteristics of the microphone. It can be used for pre-emphasis of the signal. The default response of the X filter is flat with gain equal to unity.

The R filter is an attenuation distortion correction filter for the receive path. It can be programmed to modify the characteristics of the receive path to compensate for the earpiece or loudspeaker. The R filter can also be used to add post-emphasis to the signal. The default response for the R filter is flat with gain equal to unity.

The transfer function in the frequency domain for the X and R filters is:

$$H(z) = h_0 + h_1 \cdot Z^{-1} + h_2 \cdot Z^{-2} + h_3 \cdot Z^{-3} + .. + h_7 \cdot Z^{-7}$$

where: $Z = \cos(w \cdot T) + i \cdot \sin(w \cdot T)$

and

w = Radian frequency ($2 \cdot \pi \cdot f$)

T = Sampling Rate (0.125 ms)

h_n = Coefficients. $n = (0 .. 7)$

$i = \sqrt{-1}$

APPENDIX B

COEFFICIENT REPRESENTATION

Each X and R filter coefficient is represented by a 2-byte word so that the coefficients can be programmed into the MAP using a 16-byte transfer. The MAP's X and R filter coefficient representation is based on a signed digit code. A coefficient may be represented by the following equation:

$$h_n = A_3 \cdot \{1 + A_2 \cdot [1 + A_1 \cdot (1 + A_0)]\}$$

where: $A_i = -1^{S_i} \cdot 2^{-M_i}$

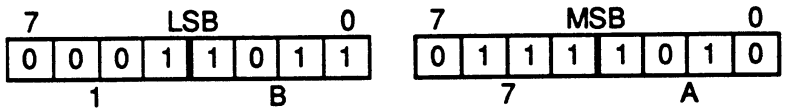
and: -1^{S_i} Gives the sign

M_i Gives the negative power of two

For example, a coefficient $h_n = 0.005$ can be represented using signed digit notation, as follows:

$$h_n = 2^{-7} \cdot \{1 - 2^{-2} \cdot [1 + 2^{-1} \cdot (1 - 2^{-3})]\}$$

which can be loaded in the MAP as:



The signed digit notation utilized in the Am79C30A provides good resolution for decimal coefficient values between 2 and –2. If any of the coefficients generated for a given application are outside that range, check the quantization error in the "Coef.Out" file. This file is generated during the Hex conversion process. The coefficients generated may be outside the –2 to 2 range if the filters are designed to provide an overall DC gain. Please refer to the Normalize command within Chapter 3.

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